Brain Structures in Verbal Communication: A Focus on Prosody

Human communication is made up of three domains: speech, language, and pragmatics, which can be fully specified as a set of rules, units, and practices. Prosodic function spans these domains. Neurolinguistic studies utilizing an array of disparate techniques reveal that many parts of the brain are required for normal communicative function. Speech and language are largely lateralized to the left cerebral hemisphere, while pragmatic competence appears to require an intact right hemisphere. Familiarity agnosias have been associated with right hemisphere dysfunction, leading to an explanation for preserved familiar proper noun recognition in severe aphasia. This model pertains to the adult brain; due to the poorly understood phenomenon of cerebral plasticity, laterality of function in children is established weakly and slowly. The basal ganglia may subserve well-known phrasal structures such as that seen in “automatic speech,” and some kinds of prosodic competence, both in production and perception. A thorough model of language and the brain takes into account two horizontal and one vertical dimension: the left-right dimension of hemispheric model differences; the anterior-posterior dimension reflecting sensory and motor processes; and the vertical interaction of cortical and subcortical processes. All of these participate crucially in the different domains of communication. Key words: aphasia, automatic speech, hemispheric specialization, neurolinguistics, right hemisphere function

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SOME DEFINITIONS

Structural descriptions of communication have changed over the past decades, but some views have endured. Most everyone agrees on the viability of certain traditional linguistic categories as a basis for describing language structure: phonetics, phonology, morphology, syntax, and linguistic semantics (e.g., Aknajian, Demers, & Harnish, 1997; Trask, 1995). These “levels” and the elements comprising them have been the focus of linguistic studies for some time; it is accepted that the basic foundation of communication is structured and is made up of discrete units and rules. One term that has been suggested for this aspect of communication is “ortholinguistics” (J.E. Bogen, personal communication, 1992). In recent years, however, studying how people actually talk has generated other topics and terms.

Communication also encompasses systematic practices of language use or pragmatics. The field of pragmatics of language is concerned with conventions of conversation, including speech formulas, speakers’ intended meanings (as in irony and sarcasm), inferences
(using world knowledge and context); nonliteral meanings (as in idioms and metaphors), and the role of topic and theme in language production and comprehension. These are all features of the larger domains of discourse and conversational interaction. Linguists study language structure; sociolinguists study talk. Talk subsumes the topics of linguistics, but expands the view to include macrounits of study. Thus, the term “speech” is best used to refer to motor output and perceptual skills; “language” covers internal, mental knowledge; “pragmatics” expands the scope of study to overall, actual language use. Prosodic competence spans these domains.

Prosody, or melody of speech, being made up of pitch, duration, intensity, and voice quality, occurs in the domain of speech, and in that capacity, can be quantified to a considerable degree. Prosodic meanings can be linguistic, as in the grammatical contrast between statement and question; or paralinguistic, as in the communication of attitudes, emotional meanings, and pragmatic factors.

Neurolinguistic studies indicate that many parts of the brain are required for normal communicative function. The basic linguistic terms mentioned here are useful for the study of aphasia and other communicative disorders. However, controversy continues over the relevance of more recent linguistic-theoretical models to the description of aphasic patterns and the usefulness of these models for treatment planning (Obler & Gjerlow, 1999).

**LEFT HEMISPHERE SPECIALIZATION FOR “ORTHOLINGUISTICS”**

As is well known since the time of Broca (1865), persons with damage in the region of the middle cerebral artery (MCA) within the left hemisphere (LH) frequently suffer from speech and language deficits, whereas persons with homologous right hemisphere (RH) damage almost never do (Benson, 1979). Little mention of brain structures, other than the LH, in communicative function appeared before the middle part of this century (Harrington, 1987). An exception lies within the notions about automatic speech described by Hughlings Jackson (1874, 1915) and Critchley (1962, 1970). Although the RH eventually became associated with visual-spatial functions (e.g., Milner, 1971, 1980), its role in communication was considered for some time to be somewhere between inconsequential and nil. This view has changed radically over the past few decades. The view has primarily involved changes in our understanding of RH involvement in communication.

Laterality to the LH of ortholinguistic function continues to be confirmed by numerous observations, including those using new technologies. Focal lesion observations, which can be documented by powerful brain scanning procedures, especially MRI, strongly support the traditional view that lesions to the left anterior-temporal-parietal area often produce aphasia. It has more recently been seen that comparable right-sided lesions lead to an array of very different communication deficits. With respect to prosodic function, evidence for cortical lateralization for emotional or linguistic prosody (Bradvik et al., 1991), whether in production or comprehension modes, has been contradictory (e.g., Ryalls, 1988; Van Lancker & Breitenstein, 1999). Mood and motivation may be important factors in dysprosodic speech (Danel et al., 1989). A significant role in communication of the
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basal ganglia-limbic system complex has been inferred from various observations, especially relating to speech prosody (Saint-
Cyr, Taylor, & Nicholson, 1995), over-
learned speech (Speedie, Brake, Folstein, 
Bowers, & Heilman, 1990), and syntax (Lieberman, Friedman, & Feldman, 1990; 
Grossman et al., 1993).

The left-sided lateralization of ortholinguistic functions is supported, although to a weaker degree, by the Wada procedure, whereby a single hemisphere is anesthetized and the other is probed for language and memory function (Loring, Meador, Lee, & King, 1992; Helms-Taylor, Kurfthen, Linke, & Elger, 1997). Incidence studies using the Wada procedure for clinical evaluation in epileptic patients reveal a range of percentage reported for bilateral representation: from 4 to 36 percent, depending on criteria, subjects, and other variables. These results are from subjects whose neurological status is compromised, and the Wada procedure shows inconsistencies across patients (Jeffery et al., 1991). Using the Wada procedure experimentally, Czopf (1981) and Kingsbury (1971) each tested a series of aphasic persons and reported that residual speech ceased in the majority of cases with right-sided injection, supporting the notion that the RH subserves speech in aphasia. This finding was supported by a report by Cummings, Benson, Walsh, and Levine (1979) that a second stroke in the RH impaired language function in an aphasic patient with an original LH stroke. Studies using the Wada procedure in nonaphasic patients, those with intractable epilepsy, have found word comprehension in the hemisphere not dominant for language (Hart et al., 1991). These observations are consistent with the model of the brain in which phonetics, phonology, syntax, and linguistic semantics are specialized to the LH, with other parameters of communication, including word meanings (especially personally relevant and emotional meanings) and pragmatics processed also by the RH. Pragmatic understanding has not yet been tested using the Wada procedure. How specialized is the RH—how exclusively lateralized—for these parameters is not yet known. The role of the RH in language recovery following stroke to the LH remains unclear (Code, 1991, 1997; Gainotti, 1993; Knopman, Rubens, Selnes, Klassen, & Meyer, 1984). Some aspects of recovery following LH stroke can be predicted from CT scan information (Naeser & Palumbo, 1994), and continued improvement of naming and speech fluency have been reported to occur even in cases where CT scan data indicated an increase of lesion size in the LH (Naeser et al., 1998).

Given the variable findings for laterality of ortholinguistic processes in clinical Wada testing, it is not surprising that use of this method to assess brain representation of speech prosody, which itself is difficult to characterize, was not successful. One such study using the Wada test claimed to demonstrate deficient ability to repeat emotionally intoned sentences following right-sided injection (Ross, Edmondson, Seibert, & Homan, 1988). However, several methodological flaws discredit the value of this reported finding. Most importantly, the authors failed to compare performance on propositional, or any other kind of nonemotional speech during right-sided injection, or obtain any performance indicating speech melody capability during left-sided Wada. This oversight is inexplicable, as a previous study (Gordon & Bogen, 1981) elicited coherent singing of a familiar song during left-
sided but not right-sided injection. There is little doubt that in the Ross et al. study (1988), the barbiturate is the immediate cause of a transient dysarthria, which included pitch and voice quality changes. This dysarthric change inevitably occurs during the initial counting activity performed by the patient (to indicate the time of arrival to the hemisphere of the drug), such that numbers are spoken with lowered pitch, rough voice quality, and impaired articulation. Thus, although preserved singing of a familiar song, reflecting relatively intact pitch control and retention of a familiar melody, has been demonstrated in the unimpaired RH in a number of studies, preserved emotional-prosodic speech has not been demonstrated.

Callosotomy studies, whereby single hemispheres of persons who have undergone sectioning of the corpus callosum (the band of fibers connecting the two cerebral hemispheres) are independently probed, also support the LH representation of ortholinguistic elements (Sperry, 1974; Bogen, 1969, 1997; see overview in Springer & Deutsch, 1997). Generally, these “split-brain” patients can name and describe pictures, words, or objects presented in the right visual field or held in their right hands, but cannot name objects presented exclusively into the left visual field or left hand. However, some patients are able to use their left hand to draw the material in the left visual field (RH), indicating that they saw (or palpated) and processed the information correctly. No studies of prosodic or pragmatic function have been attempted in split-brain patients, although one study (Sperry, Zaidel, & Zaidel, 1979) did reveal a strong emotional awareness in the isolated RH, by observing patients’ reactions to pictures of personally familiar faces, objects, and cultural symbols presented to the left visual field. In a similar vein, in his review of split-brain results, Lishman (1971) argues for independent emotional functioning in the two respective hemispheres.

Intersurgical use of stimulating electrode grids and implants in patients undergoing diagnostic procedures can also yield information about speech, language, and communicative function (Lesser et al., 1994). For example, when subdural electrode arrays placed over the left perisylvian cortex were stimulated, patients were impaired in discriminating consonants but not tones or vowels (Boatman, Hall, Goldstein, Lesser, & Gordon, 1997). Comparisons with RH function are not generally available using this technique. Direct cortical stimulation while administering language tasks is used to map language representation during surgery, usually for treatment of epilepsy or tumor (Ojemann, 1991). The hegemony of the LH for naming, the main task used in these studies, is mostly confirmed (Gordon, 1997). Some sites on the RH, when stimulated with the electrode, were associated with vocalization, speech arrest, hesitation, slurring, distortion, or repetition (Penfield & Roberts, 1966). Because the methods are of necessity confined to persons with brain damage undergoing treatment, extrapolation to normal brain organization must be made with caution.

Other techniques of study similarly address details of communication and lateral-

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If stimulating electrode in patients undergoing s can also yield infor- language, and commun- esser et al., 1994). For du- electrode arrays rysylvan cortex were were impaired in dis- but not tones or vow- Goldstein, Lesser, & parsons with RH func- ly available using this tical stimulation while ge tasks is used to map ion during surgery, usu- of epilepsy or tumor e hegemony of the LH task used in these stud- med (Gordon, 1997). when stimulated with the ated with vocalization, n, slurring, distortion, or Roberts, 1966). Because cessity confined to per- ge undergoing treatment, nal brain organization tion.
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Buchwald, Van Lancker, Erwin, Guthrie, & Schwafel, 1994).
Surprisingly, recent functional neuroimaging studies, such as Positron Emission Tomography (PET), only weakly support the classic model of speech and language lateralization (Roland, 1993). A large number of PET studies of speech and language function in unimpaired subjects has appeared. In those studies, researchers report considerable activation, sometimes greater activation, of the RH for speech production and comprehension (see Roland, 1993 pp. 269–290). From these studies, it is tempting to infer much greater involvement of the RH in speech and language function than has been previously inferred from the focal lesion data.

A few neuroimaging studies are using PET procedures to investigate prosody. Again, a range of results has been reported. For emotional prosody, a selective activation of the right prefrontal cortex was described (George et al., 1996), a finding that might be a result of the effects of working memory (Zatorre, Evans, Meyer, & Gjedde, 1992). A study of linguistic-prosodic stimuli using activated O15 PET scanning in part supported the earlier dichotic listening findings by Van Lancker and Fromkin (1973), whereby native Thai speakers but not speakers of English were found to process Thai tone-words in the LH (Gandour et al., 2000). Results from Zatorre et al. (1992) support the standard model of LH processing for phonetic contrasts in contrast to RH processing of pitch contrasts. It may be premature to base firm conclusions regarding brain function for prosody from PET results because many questions remain about interpretation of activation in PET studies using O15 to measure blood flow changes, including the legitimacy of subtraction techniques and the

stimulating implants in patients stic procedures can ion about speech, municative
role of inhibition in brain function (Friston et al., 1996; Jennings, McIntosh, Kapur, Tulving, & Houle, 1997; Sidlis, Strother, Anderson, & Rottenberg, 1999).

DEVELOPING VERSUS ADULT BRAINS

The model of cerebral laterality of ortholinguistic processes discussed here is applicable only to adults. Matters of neurological maturation, cerebral plasticity and reorganization, and other issues alter the story when discussing language laterality in children. Communicative functions in children of prepuberty age are less “established” cerebrally than in adults. For example, in young children who had suffered perinatal unilateral brain lesions, side of lesion did not affect performance on either the literal or nonpropositional portions of a language comprehension test (Kempler, Van Lancker, Marchman, & Bates, 1999). Adults, in contrast, revealed a “double dissociation,” showing poorer performance for nonliteral expressions but not novel language following RH damage, and, for LH patients, greater impairment in novel than nonliteral expressions (Van Lancker & Kempler, 1987).

It is well known that very young children undergoing a left or right hemispherectomy can develop nearly fully normal language and communicative function (Smith & Sugar, 1975; Basser, 1962), in contrast to the profound aphasia following a left hemispherectomy in adults (Burklund & Smith, 1977). However, although some report the hemispheres to be equipotential in ability to develop cognitive skills (Basser, 1962), subtle tests of formal linguistic structure reveal superior performance in some hemispherectomized children with an intact LH (Dennis & Kohn, 1975; Dennis & Whitaker, 1976). Little has been done to evaluate prosodic performance in hemispherectomized subjects. One adult, B.L., who had undergone a left hemispherectomy at the age of 5½ years, was tested on an array of language tests at the age of 49. His spontaneous speech prosody was unremarkable, and formal testing of emotional and linguistic-prosodic production was adequate. However, on formal testing, his comprehension of emotional prosody was mildly impaired (Van Lancker & Sidlis, 1992), and his comprehension of linguistic prosody fell well below normal performance (Bogen et al., 1998).

The phenomenon of cerebral “plasticity” in childhood, diminishing with the advent of puberty and adolescence, is well known, but its mechanisms and details are poorly understood. This fact makes it all the more difficult to study prosody—which is also poorly understood—in the child, especially when formal tests are used. In one study, unimpaired children younger than 7 years were unable to match tape-recorded utterances (“Johnny is walking his dog”) spoken with emotional prosody (happy, angry, sad, surprised), to facial line-drawings presented with a verbal label (Van Lancker, Kreiman, & Corneliussen, 1989). This result is troubling because ample evidence indicates that children in the first year of life use and respond to nonverbal prosodic cues (Buchwald, 1988; Crystal, 1970; Mandel, Jusczyk, & Nelson, 1994; Mehler & Christophe, 1994; Vihman & De Boysson-Bardies, 1994). The discrepancy is likely to be from the formal test constraints, not in the ability to recognize emotional prosodic information in speech. The spate of studies that have claimed an RH specialization for emotional-prosodic information pro-
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“AUTOMATIC” VERSUS “PROPOSITIONAL” SPEECH

It is often claimed or assumed that the residual utterances in severe aphasia are produced with normal sounding prosody. However, a study by De Bleser and Poeck (1985) that evaluated prosodic contours in the recurrent utterances of patients with severe aphasia revealed a stereotypy and constriction of intonation patterns in the recurrent utterances, rather than a range of contours found in normal production.

Despite the long tradition of acknowledging the ubiquitous presence of “automatic speech” as residually preserved in aphasia (Code, 1987; Van Lancker, 1973; 1988; 1994), few modern writers have discussed where in the brain these utterances are processed. Little other than anecdotal data on actual nature of residual aphasic speech were available until the work of Code (1982) on British English and Blanken (1991) on German aphasic speakers (Blanken, Wallesch, & Papagno, 1990). Code’s surveys revealed that the notion of “automatic speech” needs to be expanded, because a “Pronoun (I)+ verb” form was common (present in 14 of 75 patients). This is a common occurrence that has been overlooked in clinical descriptions. The phenomenon was discussed in Buckingham, Avakian-Whitaker, and Whitaker (1975), who described an aphasic patient using conventional sentence stems such as “I would say that...”; “I must say...”; “well gee, I’m sorry the...”; “Well the only thing I can say again is...”; “I don’t think...”; “I know... .” (p. 8). In Code’s data, expletives formed a frequent kind of recurrent utterance (11/75 patients), and other types included proper nouns (5/75), yes/no (4/75), numbers (5/75), repetitions (14/75), and other (22/75). The German data correspond closely to the British findings, with the majority consisting of (mild) expletives, interjections, speech formulas (thanking and greeting), better nouns, Pronoun (I) + verb, and other (Blanken & Marini, 1997). Questions remain about the neurological sources of recurrent utterances.

Residual aphasic output was available from a right-handed, adult patient who had undergone a left hemispherectomy, including removal of all four left cerebral lobes, limbic forebrain, left thalamus, and basal ganglia (Smith, 1966; Zangwill, 1967). During an interview 5 months after surgery, E.C. was alert but profoundly aphasic. His spontaneous speech was sparse, featuring expletives produced with normal intonation, and the words and phrases “one,” “three,” and “I” “no place,” and a range of pause fillers (“um,” “boy,” “well, yes,” “well, no,” “ah,” “and “oh”). Pause-fillers and expletives were produced with normal-sounding pragmatics and prosody. Expletives particularly contained high-spirited prosody. E.C. was unable to name anything, but he did repeat a few words (book, house, develop, November) with articulatory effort, errors, and pausing between syllables. Matching the corpora of Code (1982), Blanken and Marini (1997), and the observations of Buckingham, Avakian-Whitaker, and Whitaker (1975), he produced “sentence stems”: “I can’t,” “that’s
a,” “I don’t,” “I couldn’t say in (sic) then” with better articulation and intonation than repeated utterances. Most compellingly, E.C. sang “My country ’tis of thee” with accurate pitch intervals and facile pronunciation of nearly all the words. This observation, along with the Wada study cited above (Gordon & Bogen, 1981), leads to the conclusion that the isolated RH is capable of producing familiar songs with correct pitch intervals.

A role of the basal ganglia in normal use of automatic speech, including production of familiar songs, may be inferred from a case description by Speedie et al. (1990). In contrast to prestroke ability, a 75-year-old, righthanded man was unable to recite familiar verses, prayers, or blessings, to swear, or to sing familiar songs. As is well known, conversely, the basal ganglia are implicated in hyperactivation of interjections and expletives (coprolalia) in Tourette’s syndrome. A study of pre- and postonset usage in Parkinson’s disease of overlearned utterances, including expletives and familiar songs, which involves a different kind of basal ganglia dysfunction, could be useful in addressing these questions.

For speech production, as described previously, observations from severe aphasia reveal selective preservation of pause-fillers, speech formulas, and other conventional expressions. Counting, as a category of automatic speech, was investigated using the PET method by Van Lancker and Grafton (1997), who found LH anterior activation for normal production of words but not counting 1–10. This finding is in accord with the preservation of “automatic speech” in aphasia, and it suggests that counting may not be the optimal speech production task to use during intraoperative cortical mapping of the language areas. In comprehension, studies point to an important contribution of the RH in recognizing familiar, nonliteral expressions (Winner & Gardner, 1977; Van Lancker & Kempler, 1987; Van Lancker, 1999a).

Psycholinguistic studies on familiar nonliteral expressions reveal the complexity of these types of utterances (Honeck, 1997; Hoffman & Kemper, 1987). An idiom, proverb, or speech formula is made up of stereotyped form associated with a complex, conventionalized meaning. It was argued whether these utterances are grammatically “frozen” (Gibbs, Nayak, & Cutting, 1989) and shown that many or most of these holistic utterances can be altered by changing or adding words; some literal meanings of constituent words in idioms influence usage (Cutting & Bock, 1997; Glucksberg, 1991). Use of idioms and other conventional expressions probably reflects the interaction of two processes, memorized and newly created (Bolinger, 1976); corresponding to proposed modes of the two respective hemispheres (Bradshaw & Nettleton, 1983; Bryden, 1982; Martin, 1979; Bever, 1975; Bogen, 1969; Van Lancker, 1973).

SYNTAX AND PHONOLOGY AS LH FUNCTIONS

Newly created utterances, formed by phonological and syntactic rules operating on phonological and lexical units (Chomsky, 1957, 1965), are probably exclusively processed by the LH in the adult. Although the RH produces and understands some speech, it probably does not do so using syntactic or phonological processes. For the RH, greater articulatory facility is observed for holistic exemplars of automatic speech, compared with propositional utterances. Rhyming deficits in RH performance have also been
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**PROSODY**

Prosody is receiving increasing attention in unimpaired subjects (Banse & Scherer, 1996; Crystal, 1969; Scherer, 1986; Freese & Maynard, 1998) and subjects with brain damage. Prosody cues linguistic, attitudinal, emotional, and pragmatic information, but it has been most thoroughly studied in its role of signaling emotional meanings (Breitstein, Daum, & Ackermann, 1997). “Dysprosody” was first described as a linguistic disorder following left brain damage (Monrad-Krohn, 1947), but this author did acknowledge the various uses of prosodic contrasts (Monrad-Krohn, 1963). More recent claims about the role of the RH in modulating “the affective components of language” (Heilman, Scholes, & Watson, 1975) have not been well supported (e.g., Schlanger, Schlanger, & Gerstmann, 1976; Ryalls & Behrens, 1988; Pell & Baum, 1997a, 1997b; Shapiro & Danly, 1985; Ryalls, Joannette, & Feldman, 1987). Similarly, a functional differentiation between the linguistic and emotional functions of prosodic cues associated with left and right hemispheric performance respectively has

not held up, as both left- and right-hemisphere damaged groups have been impaired or not on either linguistic or emotional prosody, or both (Van Lancker & Breitstein, 1999; Baum & Pell, 1999).

As mentioned previously in reviewing methods of studying laterality, right auditory cortex is specialized for complex pitch perception (Sittis, 1980; Sidis & Volpe, 1988; Zatorre et al., 1992); pitch is a major cue in emotional, linguistic, and pragmatic use of prosody. Deficient pitch processing may partially account for poor RH performance on prosodic stimuli (Van Lancker, 1980; Lonie & Lesser, 1983; Van Lancker & Sidis, 1992). Deficient familiar voice recognition (phonagnosia) (Van Lancker & Canter, 1982; Van Lancker & Kreiman, 1987) has also been identified with focal damage to the right parietal lobe (Van Lancker, Kreiman, & Cummings, 1989), suggesting that complex auditory patterns, analogously to complex visual patterns, are a RH specialty (Behrens, 1989). In production, evidence from Wada testing and extreme LH dysfunction indicate an ability of the RH to sing, i.e., to manipulate motor control of pitch. Similar findings have been reported in LH damage (Danly, Cooper, & Shapiro, 1983; Ryalls & Behrens, 1988). Several production studies have performed acoustic analyses on speech of patients with LH or RH damage, yielding diverse results. A higher pitch has been reported for Broca’s aphasia (Cooper, Soares, Nicol, Michelow, 1997).

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& Goloskie, 1984; Danly & Shapiro, 1982; Ryalls, 1982; Van Lancker, Hanson, Lanto, Kempler, Jackson, Metter, & Cummings, 1988). Abnormal intonational characteristics have been found in fluent as well as nonfluent aphasic patients (Danly, Cooper, & Shapiro, 1983; Ryalls & Behrens, 1988). Most observers agree that in most cases of severe aphasia, some prosodic output function remains, in contrast to “flat” speech observed in other clinical conditions; but the prosodic forms do not attain normal range, shape, or functionality.

In speech production, timing control may be managed separately from pitch control. A specialization for fine temporal judgments has been associated with LH processing (Carmon, 1981; Robin, Tranel, & Damasio, 1990). In a study of nonfluent aphasic speech with impaired “melody,” Danly and Shapiro (1982) found the source of the dysprosody lay more in timing features than pitch. Receptive disturbances of rhythm were found in patients with LH but not in RH lesions (Oopen & Berthold, 1983) and rhythm has been associated with LH function (Robinson & Solomon, 1974). Van Lancker and Sidtis (1992) reported that LH-damaged patients’ errors in comprehension of emotional prosody in speech were attributable more to mistaking timing cues in the sentences. However, Pell and Baum (1997b) did not replicate the results on timing versus pitch cues in LH- versus RH-damaged patients. Some results on timing deficits in production have been inconsistent, with abnormalities reported for LH- and RH-damaged subjects (Hird & Kirsner, 1993; Blonder, Pickering, Heath, Smith, & Butler, 1995; Williams & Seaver, 1986).

Patients with “flat speech” resulting from various causes are communicatively handicapped. Linguistic, emotional, and pragmatic cues, normally produced in speech, are lacking. These patients may sound “depressed” or “disinterested” when the problem lies in their motor output, not their psychological state. Visual displays of the intonational contour, providing a model to match are available for speech-language therapy. One study of treatment of motor dysprosody was described by Stringer (1996), who used voice pitch biofeedback and modeling of emotional utterances. This important service to identified patients deserves broader attention and official recognition within the treatment delivery system.

MELODIC INTONATION THERAPY

Numerous clinical observations of relatively preserved prosodic function in some persons with aphasia, especially the preserved ability to sing, led to the development of Melodic Intonation Therapy (MIT), theoretically using preserved pitch control for intonational output in nonfluent patients (Helm-Estabrooks & Albert, 1991; Albert, Sparks, & Helm, 1973; Sparks, Helm, & Martin, 1974; Laughlin, Naeser, & Gordon, 1979; Helm-Estabrooks, 1983). Several of these studies report success. The technique has been most effective in Broca’s aphasia (Benson, Dobkin, Rothi, Helm-Estabrooks, & Kertesz, 1994). Recently, European studies claim success with the method (Popovic & Mihailescu, 1992; Seron, 1987). The good responses described by Naeser and Helm-Estabrooks (1985) were in subjects free of left posterior or right-sided lesions. MIT has proven a therapy of selected patient applicability and limited success. Here, again, questions arise about (1) the extent to which both hemispheres contribute to prosodic output and (2) the significance of
emotional, and pragmatically produced in speech, are trained may sound “de-estered” when the probe output, not their psychological displays of the providing a model to for speech-language treatment of motor dysfunction by Stringer et al. pitch biofeedback onional utterances. This identified patients depend on and official recognition delivery system.

ATION THERAPY observations of relational function in some especially the preserved development of Memory (MIT), theoretically control for intonational intonational deficits (Helm-Estabrooks; Sparks, & Helm, 1973; Artin, 1974; Laughlin, 1975; Helm-Estabrooks; studies report success seen most effective in conson, Dobkin, Rothi, Kertesz, 1994). Recently, assim success with the & Mihailescu, 1992; od responses described & Estabrooks (1985) were posterior or right-sided in a therapy of selected and limited success. can arise about (1) the hemispheres contribute 1(2) the significance of a role played by the basal ganglia, which may be often damaged in patients with severe nonfluent aphasia.

A PET study (Belin et al., 1996) of seven patients with severe aphasia who improved with MIT treatment is problematic in that, despite very large middle cerebral artery (MCA) lesions, subjects reportedly “reactivated” Broca’s area (on the left hemisphere) during repetition of melodically intoned speech, compared with “abnormal activation” of RH regions during repetition of normal, nonintoned speech. These results are perplexing because (1) many studies report considerable RH activation during speech in normal subjects, and (2) the early rationale for use of MIT was an efficacious engagement of intact RH mechanisms as an aid to speech production.

ROLE OF SUBCORTICAL STRUCTURES IN PROSODY

Dysprosody in both production and perception has been associated significantly with subcortical damage in stroke patients (Cancelliere & Kertesz, 1990; Starkstein, Federoff, Price, Leigarda, & Robinson, 1994; Weddell, 1994). Prosodic deficits are commonly seen in Parkinson’s disease (Blonder, Gur, & Gur, 1989; Pell, 1996; Breitenstein, Daum, & Ackermann, 1997), and in other subcortical diseases such as Huntington’s chorea (Speedie et al., 1990) and stroke (Cohen, Riccio, & Flannery, 1994; Van Lancker, Pachana, Cummings, Sistis, & Erickson, 1996). An important role of basal ganglia structures in regulating mood and motivation has recently been well documented (Ali-Cherif et al., 1984; Mayeux, 1983; Mendez, Adams, & Lewandowski, 1989); mood and motivational deficits have an impact on voice prosody (Bhatia & Marsden, 1994; Ellgring & Scherer, 1996; for review, see Van Lancker & Breitenstein, 1999).

Early on, from a literature review and visual-acoustic records of single cases, Kent and Rosenbek (1982) presented a model of speech production that has proven to be a workable scheme for expressive prosodic disturbances, presenting multiple cerebral sites. They correctly observed many similarities between the speech pattern of patients with right-cerebral lesion and patients with Parkinson’s disease (p. 260) and they included dysprosody associated with LH (LH), as well as cerebellar damage. Of course, impaired speech melody is included as a characteristic feature of nonfluent aphasia in the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1972). A similar overview of production is given by Ackermann, Hertrich, and Ziegler (1993), reviewing dysprosodic output deficits in patients with LH and RH damage and in patients with Huntington’s and Parkinson’s diseases. These authors also consider the respective roles of “planning” or higher control versus peripheral (articulatory and phonatory) functions as variously underlying the clinical presentation of dysprosody.

EMOTIONAL EXPERIENCING IN THE RIGHT HEMISPHERE

The first known mention of the role of the RH in emotional experiencing was by Mills (1912), who disclaims being the origin of the notion: “It not a new idea that the right hemisilure plays a larger part in the realization, control and excitation of emotions than the left” (p. 167). Despite the bilateral neuroanatomical basis of structures known
to be involved in emotional functions (Papez, 1937), evidence indicates that emotional experiencing has greater representation in the RH, as seen in findings for lexical, facial, and gestural processing (Bear, 1983; Borod, 1992, 1993; Hornak, Rolls, & Wade, 1996). Borod et al. (1996) recorded RH- and LH-damaged subjects during the description of personally relevant emotional (seven emotions) and nonemotional (characteristics of people) experiences in an attempt to elicit spontaneous emotional expression. From two raters' judgments of "emotionality" on a six-point scale, RH-damaged patients produced less emotional content than the control group, but they did not differ from the LH-damaged group. Related are observations that emotional disorders are often associated with RH damage (Cummings, 1985, 1997; Cutting, 1990; Heilman, Watson, & Bowers, 1983; Robinson, Kubos, Starr, Rao, & Price, 1984; Schiffer, 1996).

Persons with RH damage have told stories with less emotive and specific content than matched normal subjects (Wechsler, 1973; Cimino, Verfaellie, Bowers, & Heilman, 1991) or have shown reduced emotional sensitivity across stimuli (Cicone, Wapner, & Gardner, 1980). Aphasic patients were reported to read emotional words more correctly (presumably using the intact RH) than concrete or nonemotional abstract words (Landis, Graves, & Goodglass, 1982). Interestingly, lexical organization appears to differ in the respective hemispheres, with personal affect and real-world context playing a relational role in how words are associated in the RH (Sidtis, Volpe, Holtzman, Wilson, & Gazzaniga, 1981; Drews, 1987) whereas linguistic associations (typicality, hierarchical organization) may better characterize lexical structure in the LH. Various studies suggest differing lexical systems in the respective hemispheres (Chiarello, 1988b; Landis & Regard, 1988; Landis, Regard, Graves, & Goodglass, 1983), accounting for some instances of deep dyslexia seen in aphasia (Van Lancker, 1990a). Rapcsak, Kaszniak, & Rubens (1989) reported a case of anomia for facial expressions associated with right temporal lobe dysfunction. Impoverishment of emotional words was observed in storytelling by split-brain patients (TenHouten, Hoppe, Bogen, & Walter, 1986). Calling this condition "alexithymia," the explanation involved a lack of communication to the speaking LH from the affective repertory of the right. Bowers, Bauer, and Heilman (1993) coined the term "affective lexicon" to describe the specialization of the RH.

The preservation of proper noun comprehension (Van Lancker & Klein, 1990; Collins, 1991; Wallace & Canter, 1985; McNeil, Cipolotti, & Warrington, 1994; Wapner & Gardner, 1979; Van Lancker & Nicklay, 1992) as well as proper noun production (Code, 1982) in patients with global aphasia are likely attributable to RH function. The preserved ability may result in part from the emotive and familiar content of personally relevant names. One possibility is that the RH is specialized for information that is personally relevant and therefore carries an emotional valence (Van Lancker, 1991). Support for this notion is seen in disturbances of the familiarity sensation, as in Capgras syndrome and otheragnosias, in RH damage (Ellis, 1994; Cutting, 1990). Split-brain studies reviewed above (e.g., Lishman, 1971) describe a notable emotional life in the isolated RH, with a stronger response from the separated RH than the LH to personal emotional pictures (Sperry, Zaidel, & Zaidel, 1979).
LINGUISTIC CATEGORIES REFLECTED IN APHASIC SPEECH

Models of language have changed significantly over the years of studies in generative linguistics, leading to difficulty in successfully relating these models to observations in psychological studies (Reber, 1987) or aphasia. As various models have been explored, there has been only scant indication of “psychological reality” of linguistic units and rules in the study of aphasic speech. For example, it remains controversial whether “agrammatic” aphasia is characterized primarily by grammatical or semantic deficits (Bates & Goodman, 1997). Instead, other descriptive parameters have served better in neurolinguistic studies. The key descriptive parameter for aphasic speech is, first, fluent versus nonfluent. Another important factor, not of any relevance to linguistic models, is the differentiation of processing modes: production, repetition, and comprehension. Aphasic persons manifest radically different performance abilities depending on the task requested of them. Length, text frequency, and complexity play a large role in performance. Another strong contender for describing aphasic speech—one that is foreign to most contemporary linguistic descriptions—is “overlearned” (or holistically processed) versus “novel” (or newly created), corresponding to the Jacksonian automatic-propositional distinction (Van Lancker, 1988). A similar, recently proposed descriptive dichotomy is useful in classifying aphasic speech output: modal versus referential (Nespoulous, Code, Virbel, & Lecours, 1998). Modal speech includes relatively fluent and conventional expressions of attitude, but it lacks informational content, in contrast to referential speech.

One linguistic-structural category that is observed in speech-language pathology is the distinction between syntax and semantics. Many patients (e.g., persons with Wernicke’s aphasia or Alzheimer’s disease) produce syntactically intact structures (Kempler, 1991), but the meaning is severely impoverished; conversely, persons with nonfluent aphasia or Parkinson’s disease are impaired or restricted in generating syntactic phrases, but produce semantically intact information (Van Lancker, 1999b). However, many aphasias are of the “mixed” variety, combining semantic and grammatical problems.

PRAGMATICS OR THE STUDY OF LANGUAGE USE

Pragmatics is a topic of considerable recent productivity in communication research (e.g., Brownell & Joanette, 1993; Joanette, goulet, & Hannequin, 1990; Van Lancker, 1997; Chiarello, 1988a). Persons may know all the words and the grammar that combine them, but to engage in communication, it is necessary to perform operations of all kinds across larger stretches of talk (Beeman & Chiarello, 1998; Brownell & Joanette, 1993; Joanette & Brownell, 1990; Peresman, 1983; Young, 1983; Chiarello, 1988b). The RH plays a role in important parameters of communication (Brownell & Martin, in press; Molloy, Brownell, & Gardner, 1990); such as performing inferences (Brownell, Potter,

Persons may know all the words and the grammar that combines them, but to engage in communication, it is necessary to perform operations of all kinds across larger stretches of talk.
Bihrlle, & Gardner, 1986; Gardner, Brownell, Wapner, & Michelow, 1983); context involving personal reference (Brownell, Pincus, Blum, Rehak, & Winner, 1997); indirect requests as studied by Searle (1975) and (Weyrman, Brownell, Roman, & Gardner, 1989); and ability to appreciate humor (Brownell, Michel, Powelson, & Gardner, 1983; Bihrlle, Brownell, Powelson, & Gardner, 1986). Patients with RH damage are communicatively handicapped in ways that impact seriously on their daily function and require attention from rehabilitation professionals (Boss, 1996). Evaluation protocols and treatment handbooks have appeared to meet this need (e.g., Kempler & Van Lancker, 1996; Pimental & Kingsbury, 1989; Burns, Halper, & Mogil, 1996; Tompkins, 1996).

OVERVIEW OF LEFT VERSUS RIGHT HEMISPHERE ROLES IN COMMUNICATION

There is little of morphology or syntax demonstrable as part of the RH function. These ortholinguistic properties are exclusive residents of the LH. Grammatical deficits—impoverishment of function words and affixes—are seen in left anterior damage; grammatical processing is associated with an intact adult LH. An interesting apparent counterexample comes from sentence stems (Pronoun + verb) used by individuals with severe aphasia as mentioned above (Buckingham, Avakian-Whitaker, & Whitaker, 1975). However, sentence stems have been classed by linguists Pawley and Syder (1980) as conventional expressions, in the same category as speech formulas (Fillmore, 1979), idioms, or proverbs (Van Lancker, 1990b), in the class of memorized expressions that pervade normal language use (Bolinger, 1976). The question has arisen about the source of the “modular” speech of fluent aphasia; Nespoulous et al. (1998) speculate that an interaction of RH and basal ganglia structures may account for the emotional-attitudinal content of modular speech. This suggestion accounts for the preservation of conventional expressions that may be seen as overlearned vocal-motor gestures.

Lexical storage and processing occur in both hemispheres, probably following different organizational properties. Claims about separate conceptual-linguistic categories, such as an inanimate/animate distinction, associated with cortical localization in the left temporal lobe, are enjoying an ongoing debate (Caramazza, Hillis, Leek, & Miozzo, 1994). Relating lexical items to affective and contextual material may be a specialization of the RH. Similarly, pragmatic factors of many kinds have been shown to be processed in the RH. These factors include inference, figurative meanings, indirect and implied meanings, maintenance of theme and topic, conversational format, and appropriate recognition of the knowledge of the other talker. The affective function of the RH, combined with its specialization for processing of pitch contrasts and pitch patterns, account for emotional-prosodic processing deficits following RH damage.

THE ROLE OF SUBCORTICAL STRUCTURES

A video program titled “The Two Brains” (NOVA documentary) begins by celebrating the unique evolutionary achievement of humans in having “complex language.” The new ability is said to be “due to the cerebral cortex,” “an amazing network of cells,” and
vade normal language. The question has arisen he “modular” speech of poulous et al. (1998) fraction of RH and basal account for the emotion of modular speech, counts for the preservation expressions that may be vocal-motor gestures and processing occur in probably following dif- ficulties as a whole. Trials on RT and linguistic categorical/animate/distinguish cortical localization in be, are enjoying an ongo- na, Hills, Leek, & ating lexical items to actual material may be a whole. Similarly, prag- matic kinds have been shown to the RH. These factors figurative meanings, indi- cations, maintenance of conversational format, and ition of the knowledge of affective function of the brain its specialization for contrasts and pitch-pitch- emotional-prosodic lowering RH damage.

SUBCORTICAL

n titled “The Two Brains” tary) begins by celebrating porcine achievement of human complex language.” The it to be “due to the cerebral ring network of cells,” and “the outer layer of the brain.” The narrator explains that the cortex began to develop more quickly with the “dawn of man.” This description typifies an earlier view of brain and language behavior relationships that focuses on cortical regions. More recently, subcortical nuclei, such as the basal ganglia and the limbic system, have come into awareness as constitutive to communicative function. Students of evolution have noted how basal ganglia structures have also evolved in size and complexity (Lieberman, 1991) and that the greatest elaboration of the cortical mantle occurred in prefrontal areas; in this regard, the role of frontosubcortical structures in higher human functions, including syntax, has been brought into focus (Breitenstein, Daum, & Ackermann, 1997; Lieberman, Friedman, & Feldman, 1990; Cummings, 1993).

The limbic system is also relevant to communication, possibly forming one of two evolutionary paths of development (Robinson, 1976; Ploog, 1979). These questions become especially pertinent in studying the emotional vocalizations of Tourette’s syndrome, where arguments for limbic dysfunction have been proposed (Ludlow, Polinsky, Caine, Bassich, & Ebert, 1982; Comings, 1987; Singer, 1997; Robertson, Doran, Trimble, & Lees, 1990).

COMMUNICATION, PROSODY, AND THE BRAIN

An understanding of cerebral bases of verbal and prosodic communication requires a multidimensional perspective. Most pertinent to this understanding are hemispheric modes, which determine that phonology and syntax will be lateralized to the LH, and context-determined macrounits of communication, which will be lateralized to the RH. This dimension explains most findings in aphasia: LH but not RH damage interferes with ortholinguistic function; RH but not LH damage interferes with pragmatic functions. Secondly, processes of sensation/perception/comprehension must be separated from motoric/productive ones. In this perspective, it is necessary to consider the depth of motor planning function and the possibly highly intimate relationship of the basal ganglia to cortical functions of the respective hemispheres. On this dimension, the hemispheric anterior-posterior axis (corresponding with motor versus sensory abilities) interfaces with a cortical-subcortical axis. This dimension can be invoked to explain findings that patients with Parkinson’s disease are deficient in comprehending syntax (Grossman et al., 1993; Cummings & Benson, 1989; Lieberman, Friedman, & Feldman, 1990) as well as producing complex syntactic structures (Gordon & Illes, 1987; Illes, Metter, Hanson, & Iritani, 1988), and patients with subcortical damage are impaired in comprehension as well as production of emotional prosody (Cancelliere & Kertesz, 1990). Overlearned expressions that make up a large portion of human communication may well proceed by interaction of basal ganglia and RH processes. These include highly routinized phrases, apparently “syntactic” in nature; evidence from aphasic and left-hemisphere-tocom (adult) patients leads to this conclusion. Basal ganglia structures in concert with those of the limbic system may significantly underlie use of affective terms, including expletives; evidence from Gilles de la Tourette’s disease and from some studies of stroke patients point in this direction. Evidence from brain-damaged and split-brain subjects implicates the RH in emotional experiencing.
Studies of affective and linguistic prosody over the past 25 years indicate a greater complexity underlying prosodic processing than first acknowledged (Baum & Pell, 1999). Successful emotional-prosodic production requires an intact ability to produce pitch and timing cues in speech, as well as normal motivation and mood states. Similarly, emotional-prosodic comprehension involves perception of the subtle timing and pitch perceptual cues in speech, as well as possible RH abilities to recognize appropriate configurations corresponding to a kind of “affect lexicon,” which draws on a greater ability of the RH to participate in emotional phenomena in various formats. The role of hemispheric modes is tantamount also in processing of prosodic information. Therefore, it is predictable that persons with either LH or RH damage would be impaired in prosodic comprehension and production, as temporal and pitch abilities are apparently lateralized to the LH and RH respectively. The “vertical” dimension must also be considered in the overall perspective because mood and motivation, as well as motor planning and control, are associated with basal ganglia functioning.

The speech-language clinician can use the left-right hemispheric dimension in evaluating ortholinguistic versus pragmatic functioning in patients with communicative disorders. In speech-language disorders, the anterior-posterior dimension, corresponding to production and comprehension, must be considered with care because subcortical influence plays a major role in production and comprehension skills. An even greater complexity is found in prosodic evaluation, in which comprehension deficits may be difficult to demonstrate, whereas production deficits may be easy to hear but difficult to describe in terms of acoustic cues and even more difficult to correlate neuroanatomically. Although the field of pragmatic disorders has developed a rich literature in evaluation and treatment techniques, prosodic studies have yet to yield the variety of useful materials necessary to explore an adequate range of clinical presentations. This topic is rife for applied studies.

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